# NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

## TECHNICAL NOTE 4296

# COMPRESSIVE STRENGTH AND CREEP OF 17-7 PH STAINLESS-STEEL PLATES AT ELEVATED TEMPERATURES

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## SUMMARY

Compressive strength test results from room temperature to 1,000° F and compressive creep test results from 700° F to 1,000° F are presented for plates of 17-7 PH stainless steel, Condition TH 1,050, which were edge-supported in V-groove fixtures. Plate width-thickness ratios range from 15 to 60. The combinations of average stress, temperature, and time that produce given amounts of creep strain or failure are shown on master curves which facilitate interpolation of the test results. The test results are compared with plate strengths and creep failure stresses determined from semiempirical approximations.

## INTRODUCTION

Precipitation-hardening stainless steels are finding increasing use in aircraft structures because of their satisfactory elevated-temperature properties and the fact that they can be easily fabricated in the annealed condition, with the strength of the fabricated parts being substantially increased by subsequent heat treatment. Since plates are important load-carrying members of aircraft structures, the present investigation was undertaken to obtain experimental data on the strength and creep behavior of plates made of 17-7 PH stainless steel, one of these precipitation-hardening alloys. This investigation of stainless-steel plates is a continuation of the work reported in references 1 and 2 for aluminum-alloy plates.

Compressive strength and creep properties of 17-7 PH stainless-steel plates determined in an elevated-temperature testing program are presented for plate width-thickness ratios ranging from 15 to 60 over a temperature range from room temperature to 1,000° F. The test results are compared with data predicted by semiempirical methods. These data were calculated by using procedures for correlating plate strength and creep properties with elevated-temperature materials data in a manner similar to that described in reference 1. The experimental creep results are analyzed and presented in the form of master curves which facilitate interpolation of the test results.

## SYMBOLS

| | |
|---|---|
| A, B, k | material creep constants |
| $b$ | width of plate, in. |
| C, m, n | constants |
| $E$ | Young's modulus, ksi |
| $E_s$ | secant modulus, ksi |
| $t$ | thickness of plate, in. |
| R. T. | room temperature |
| $T$ | temperature, $^{\circ}F$ |
| $T_R$ | absolute temperature, $^{\circ}R$ |
| $\epsilon$ | strain |
| $\bar{\epsilon}$ | unit shortening |
| $\bar{\epsilon}_f$ | unit shortening at maximum (failing) load |
| $\eta$ | nondimensional plasticity correction factor |
| $\sigma$ | stress, ksi |
| $\bar{\sigma}$ | average stress, ksi |
| $\sigma_{cr}$ | critical (buckling) stress, ksi |
| $\sigma_{cy}$ | 0.2-percent-offset compressive yield stress, ksi |
| $\bar{\sigma}_f$ | average stress at maximum (failing) load, ksi |

$\tau$ creep time, hr

$\tau_f$ failure time, hr

## SPECIMENS, EQUIPMENT, AND PROCEDURES

The plate specimens tested in the present investigation were machined from the same 0.050-inch-thick 17-7 PH stainless-steel sheet that was used in the material stress-strain test program reported in reference 3. The plate specimens were machined 16 inches long with the specimen length oriented parallel to the rolling direction of the sheet. The widths of the specimens were selected so that the nominal width-thickness ratios were 15, 20, 30, 40, and 60. The stress-strain specimens (ref. 3) and the plates tested in this investigation were heat-treated to Condition TH 1,050 according to the manufacturer's instructions as follows: The annealed 17-7 PH stainless-steel plate specimens were heated at 1,400° F ± 25° F for $1\frac{1}{2}$ hours, air-cooled to 60° F within 1 hour after removal from the furnace, heated at 1,050° F ± 10° F for $1\frac{1}{2}$ hours, and then air-cooled.

The compressive-strength tests of the plates were performed at temperatures ranging from room temperature to 1,000° F. All plates were exposed to the test temperature for $\frac{1}{2}$ hour prior to loading. The rate of loading was controlled to give a nominal rate of unit shortening of 0.002 per minute. The testing and recording equipment used in the present investigation is shown in figure 1. In order to show the V-groove fixture and the specimen, the furnace was removed and placed near the testing machine. The equipment and procedures are similar to those described in reference 1 except that chromel-alumel thermocouples were used in this investigation. A small clamping force was required to keep the specimen alined in the V-grooves.

The V-groove fixture which supported the edges of the specimen during the test is shown in figure 2. This type of fixture was used in the investigation because the maximum strengths of plates supported in V-grooves correlate closely with the maximum strengths of plate assemblies such as stiffened panels (ref. 4). In addition, limited results on the creep of stiffened panels appear to show satisfactory correlation with creep results of plates in V-grooves (ref. 5).

Compressive creep tests covered a temperature range from 700° F to 1,000° F. Creep tests at 700° F were made for width-thickness ratios of 15 and 20 only. For the other width-thickness ratios (30, 40, and 60) collapse would not occur within the predetermined limiting testing time of 15 hours unless the applied stress were practically coincident with the average stress to produce instantaneous collapse of the plate. At 800° F, 900° F, and 1,000° F, plate creep data were obtained by tests of plates of all width-thickness ratios. The compressive creep properties for the material were assumed to be given by the test results for plates with width-thickness ratios of 15 and 20 at stresses which would not produce buckling during the initial portions of the tests.

## COMPRESSIVE STRENGTH

### Experimental Results

The maximum compressive strengths of 17-7 PH stainless-steel plates are presented in table I for temperatures up to 1,000° F. Average stress is plotted against unit shortening in figure 3 for each of the plate strength tests. The curves in figure 3 indicate that buckling and collapse occur at approximately the same stress for width-thickness ratios of 15 and 20. The plates with width-thickness ratios of 30, 40, and 60 showed some strength beyond buckling. Buckling is associated with the break in the curve of average stress against unit shortening. For the width-thickness ratios of 30, 40, and 60, the value of unit shortening at which buckling took place showed a tendency to decrease slightly with increasing temperature.

For a width-thickness ratio of 15, maximum strength was obtained in the vicinity of 1 percent shortening. For all other width-thickness ratios, maximum strength was obtained in the vicinity of 0.5 percent shortening.

Material compressive stress-strain curves for the 17-7 PH stainless steel, Condition TH 1,050, used in the present investigation are shown in figure 4, and secant moduli for these stress-strain curves are plotted against stress in figure 5. These curves are reproduced from figures 2 and 6 of reference 3.

### Estimation of Short-Time Maximum Compressive Strength

Several investigators (for example, refs. 4 and 6) have proposed the following type of equation for determining maximum strengths of plates in V-groove fixtures:

$$\bar{\sigma}_f = C\left(\eta E \sigma_{cy}\right)^m \left(\frac{t}{b}\right)^n \tag{1}$$

Equation (1) was applied with good results for 2024-T3 aluminum-alloy plates in reference 1 and for 7075-T6 aluminum-alloy plates in reference 2 by using $\eta E = E_s$, $m = 1/2$, $n = 1$, and $C = 1.60$. Equation (1) thus reduces to

$$\bar{\sigma}_f = 1.60 \sqrt{E_s \sigma_{cy}} \frac{t}{b} \tag{2}$$

which is used in the present investigation for determining maximum strengths of the 17-7 PH stainless-steel plates. In equation (2), $E_s$ (fig. 5) is evaluated at the stress $\bar{\sigma}_f$. The value of $\sigma_{cy}$ is determined from the elevated-temperature material compressive stress-strain curves (fig. 4). Maximum plate strengths calculated from equation (2) for 17-7 PH stainless-steel plates at temperatures up to 1,000° F and width-thickness ratios from 15 to 60 are plotted as solid lines in figure 6. The test results are shown as symbols. There is good agreement between the calculated and experimental results throughout the range of test temperatures.

## COMPRESSIVE CREEP

### Experimental Results

Compressive creep data for 17-7 PH stainless-steel plates obtained in this investigation are summarized in table II. Typical creep curves from these tests are shown in figure 7 for the complete ranges of testing temperatures and width-thickness ratios. The shortening shown at time equal zero is the shortening of the plate obtained immediately upon application of the load.

Qualitatively, the behavior of 17-7 PH stainless-steel plates in the creep tests resembled that of the aluminum alloys (refs. 1 and 2). The buckles appeared gradually along the entire length of the plate and grew in depth until collapse occurred.

### Time-Temperature-Parameter Presentation of Creep Data

Lifetimes.- In references 1, 2, and 7, a time-temperature parameter $T_R\left(C + \log_{10} \tau_f\right)$ was used to present compressive creep data of structural elements in order to simplify interpolation of the creep data. In using this same parameter, a value of 25 for the constant C was found to reduce the compressive creep data for 17-7 PH stainless-steel plates to two straight lines on a semilogarithmic plot for each plate proportion. Such curves, shown in figure 8, are known as master creep lifetime curves. The solid curves in the figure represent average values of the test results (symbols). With this plot, it is possible to predict stresses, temperatures, and times that produce failure within the ranges covered by the test data.

In figure 8, the intersection of the two straight lines for each width-thickness ratio occurs at a value of time-temperature parameter of approximately 33,250. It may be noted that this same value (33,250) is obtained from substitution of the exposure time of $\frac{1}{2}$ hour for $\tau_f$ and the equicohesive temperature (approximately 1/2 of the melting temperature of the material on an absolute temperature scale) of 17-7 PH stainless steel for $T_R$ in the time-temperature parameter.

Creep strain.- The master creep lifetime plot provides a convenient method for estimating failure times of the 17-7 PH stainless-steel plates for various combinations of stress, temperature, and time. In many cases, however, structural deformation may limit the usefulness of a structure and for this reason creep deformation, rather than failure, may be significant. The combination of stress, temperature, and time which will produce given magnitudes of creep strain can also be shown in the form of master plots. Such plots are presented in figures 9 and 10 for creep-strain values of 0.0002 and 0.002, respectively. These values of creep strain were assumed in reference 8 to be significant in the deformation of aircraft structures. A creep strain of less than 0.0002 was considered to produce negligible permanent structural deformation; creep strains larger than 0.002 were assumed to produce permanent structural deformations which would, in many cases, deform the structure beyond the range of usefulness. Results of representative tests are plotted as symbols in figures 9 and 10. The lines are average values of the test results. Again, the creep data for each plate proportion form two straight lines intersecting at a value of time-temperature parameter of 33,250, which is equal to the value obtained when $T_R$ is the equicohesive temperature and $\tau$ is $\frac{1}{2}$ hour.

## Estimation of Compressive Creep Failure Stresses

In this section, a semiempirical method is presented for predicting creep failure stresses of 17-7 PH stainless-steel plates solely on the basis of material compressive creep data. This type of approach has been used for 2024-T3 aluminum-alloy plates in reference 1 and

7075-T6 aluminum-alloy plates in reference 2. The method utilizes material creep data in the form of isochronous compressive stress-strain curves. Isochronous stress-strain curves are creep curves plotted in the form of stress against strain for constant times. The curves indicate the sum of the strain produced immediately on application of a given stress and the creep strain obtained at that stress for the various times.

Since no material compressive creep data for 17-7 PH stainless-steel sheet were available, the material compressive creep curves were assumed to be given by the tests at low stresses of plates with width-thickness ratios of 15 and 20. The initial portion of these creep curves was approximated by the expression

$$\epsilon = \frac{\sigma}{E_s} + A\tau^k \sinh(B\sigma) \tag{3}$$

The material creep constants A, B, and k for this expression are listed in table III. In figure 11, the experimental material creep curves obtained from plate tests at width-thickness ratios of 15 and 20 (solid lines) and the curves calculated from equation (3) (dashed lines) are compared. Isochronous stress-strain curves were calculated from equation (3) and are shown in figure 12.

Creep failure stresses were calculated in a manner similar to that used for the plate-strength calculations. Equation (2) was applied as before, but the appropriate isochronous stress-strain curves were substituted for the material stress-strain curves. In figure 13, the calculated creep failure stresses for 17-7 PH stainless-steel plates are shown as solid lines and are compared with the experimental data (symbols) for the range of width-thickness ratios investigated. The agreement of experimental and calculated values is satisfactory. At 700° F, only a few test points were obtained for width-thickness ratios of 15 and 20 and no data were obtained for width-thickness ratios of 30, 40, and 60; therefore, comparisons are made in figure 13 for temperatures of 800° F, 900° F, and 1,000° F only.

## CONCLUDING REMARKS

Elevated-temperature compressive strength and creep tests have been made of 17-7 PH stainless-steel plates, Condition TH 1,050, which were edge-supported in V-groove fixtures. The results have been presented and compared with predicted maximum strength and creep failure stresses determined from semiempirical methods. The correlation between the experimental and calculated plate strengths is good. The comparison between the experimental creep failure stresses and the failure stresses determined from isochronous stress-strain data is satisfactory. The combinations of average stress, temperature, and time that produce given amounts of creep strain or failure are shown on master curves which facilitate interpolation of the test data.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., April 14, 1958.

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TABLE I.- COMPRESSIVE STRENGTH OF 17-7 PH STAINLESS-STEEL PLATES

[$\frac{1}{2}$-hour temperature exposure prior to loading]

| Specimen | T, °F | b/t | $\bar{\sigma}_f$, ksi | $\sigma_{cr}$, ksi | $\bar{\epsilon}_f$ |
|---|---|---|---|---|---|
| 1 | R.T. | 14.53 | 189.5 | 189 | 0.0101 |
| 2 | R.T. | 20.01 | 169.0 | 168 | .0067 |
| 3 | R.T. | 29.95 | 121.3 | 110 | .0049 |
| 4 | R.T. | 40.22 | 90.2 | 67 | .0055 |
| 5 | R.T. | 61.98 | 61.2 | 30 | .0061 |
| 6 | 400 | 14.53 | 181.2 | 181 | .0112 |
| 7 | 400 | 19.63 | 175.5 | 175 | .0065 |
| 8 | 400 | 30.30 | 114.4 | 96 | .0047 |
| 9 | 400 | 42.21 | 87.3 | 65 | .0047 |
| 10 | 400 | 61.25 | 60.5 | 30 | .0054 |
| 11 | 600 | 14.64 | 167.5 | 167 | .0110 |
| 12 | 600 | 19.72 | 150.0 | 150 | .0069 |
| 13 | 600 | 31.04 | 108.0 | 105 | .0045 |
| 14 | 600 | 42.12 | 82.8 | 57 | .0048 |
| 15 | 600 | 61.99 | 58.3 | 27 | .0052 |
| 16 | 800 | 14.85 | 143.5 | 143 | .0123 |
| 17 | 800 | 19.94 | 131.0 | 131 | .0068 |
| 18 | 800 | 31.37 | 94.9 | 90 | .0043 |
| 19 | 800 | 41.28 | 71.3 | 53 | .0050 |
| 20 | 800 | 57.82 | 53.5 | 25 | .0057 |
| 21 | 1,000 | 14.60 | 75.5 | 75 | .0080 |
| 22 | 1,000 | 20.93 | 71.5 | 71 | .0059 |
| 23 | 1,000 | 30.54 | 62.5 | 60 | .0043 |
| 24 | 1,000 | 40.44 | 42.9 | 41 | .0034 |
| 25 | 1,000 | 61.49 | 35.8 | 20 | .0042 |

TABLE II.- CREEP TEST RESULTS FOR 17-7 PH STAINLESS-STEEL PLATES

[All plates were exposed to test temperature for $\frac{1}{2}$ hour prior to loading]

| Specimen | T, °F | b/t | $\bar{\sigma}$, ksi | $\frac{\bar{\sigma}}{\bar{\sigma}_f}$ | $\tau_f$, hr |
|---|---|---|---|---|---|
| 26 | 700 | 14.50 | 134.2 | 0.850 | 1.75 |
| 27 | 700 | 14.59 | 131.1 | .830 | 3.75 |
| 28 | 700 | 15.37 | 129.6 | .820 | 6.90 |
| 29 | 700 | 16.40 | 128.0 | .810 | (a) |
| 30 | 800 | 15.37 | 113.6 | .800 | 1.01 |
| 31 | 800 | 15.21 | 110.7 | .780 | 1.68 |
| 32 | 800 | 14.77 | 106.5 | .750 | 5.50 |
| 33 | 800 | 14.66 | 105.0 | .740 | 1.85 |
| 34 | 800 | 16.25 | 102.2 | .720 | 4.10 |
| 35 | 800 | 14.95 | 97.9 | .690 | 4.67 |
| 36 | 900 | 14.61 | 82.1 | .750 | .90 |
| 37 | 900 | 14.73 | 80.0 | .731 | 1.15 |
| 38 | 900 | 14.87 | 73.4 | .670 | 3.40 |
| 39 | 900 | 14.60 | 69.0 | .630 | 8.00 |
| 40 | 900 | 14.72 | 65.7 | .600 | 15.50 |
| 41 | 1,000 | 14.91 | 56.0 | .720 | .72 |
| 42 | 1,000 | 14.57 | 53.0 | .682 | 1.60 |
| 43 | 1,000 | 14.53 | 49.0 | .629 | 3.50 |
| 44 | 1,000 | 14.51 | 45.0 | .578 | 7.10 |
| 45 | 1,000 | 14.58 | 42.0 | .540 | 8.80 |
| 46 | 1,000 | 14.81 | 20.0 | .257 | (a) |
| 47 | 700 | 19.57 | 118.0 | .830 | 3.50 |
| 48 | 700 | 19.61 | 113.6 | .800 | 3.42 |
| 49 | 700 | 20.93 | 110.0 | .774 | (a) |
| 50 | 700 | 20.99 | 100.0 | .704 | (a) |
| 51 | 800 | 19.92 | 97.5 | .750 | 1.09 |
| 52 | 800 | 20.60 | 95.0 | .730 | 1.55 |
| 53 | 800 | 19.78 | 91.0 | .700 | 7.40 |
| 54 | 800 | 19.45 | 70.0 | .539 | (a) |
| 55 | 800 | 19.49 | 60.0 | .461 | (a) |
| 56 | 900 | 19.53 | 80.0 | .800 | .33 |
| 57 | 900 | 19.66 | 75.0 | .750 | .75 |
| 58 | 900 | 20.44 | 70.0 | .700 | 2.10 |
| 59 | 900 | 19.42 | 65.0 | .650 | 4.50 |
| 60 | 900 | 19.61 | 60.5 | .600 | 8.00 |
| 61 | 900 | 20.02 | 50.0 | .500 | (a) |
| 62 | 900 | 19.56 | 35.0 | .350 | (a) |

[a]Test stopped before failure.

TABLE II.- CREEP TEST RESULTS FOR 17-7 PH STAINLESS-STEEL PLATES - Concluded

| Specimen | T, °F | b/t | $\bar{\sigma}$, ksi | $\frac{\bar{\sigma}}{\bar{\sigma}_f}$ | $\tau_f$, hr |
|---|---|---|---|---|---|
| 63 | 1,000 | 20.49 | 55.0 | 0.753 | 0.34 |
| 64 | 1,000 | 20.66 | 50.0 | .685 | .74 |
| 65 | 1,000 | 19.78 | 48.0 | .657 | 1.30 |
| 66 | 1,000 | 20.26 | 46.0 | .630 | 1.70 |
| 67 | 1,000 | 20.76 | 40.0 | .548 | 4.60 |
| 68 | 1,000 | 20.79 | 35.0 | .480 | 15.50 |
| 69 | 1,000 | 20.72 | 30.0 | .411 | (a) |
| 70 | 1,000 | 21.00 | 25.0 | .343 | (a) |
| 71 | 800 | 30.50 | 77.9 | .820 | 1.79 |
| 72 | 800 | 30.07 | 76.1 | .800 | 3.30 |
| 73 | 800 | 29.66 | 74.2 | .780 | 4.52 |
| 74 | 800 | 30.60 | 73.2 | .770 | 5.25 |
| 75 | 800 | 30.07 | 72.2 | .760 | 9.67 |
| 76 | 900 | 29.59 | 60.0 | .774 | 1.10 |
| 77 | 900 | 29.60 | 50.0 | .645 | 8.50 |
| 78 | 1,000 | 30.19 | 40.0 | .684 | .72 |
| 79 | 1,000 | 30.92 | 37.0 | .633 | 1.10 |
| 80 | 1,000 | 29.65 | 35.0 | .599 | 1.75 |
| 81 | 1,000 | 30.75 | 30.0 | .513 | 7.50 |
| 82 | 800 | 40.06 | 59.1 | .820 | .67 |
| 83 | 800 | 41.71 | 57.6 | .800 | 3.50 |
| 84 | 800 | 40.22 | 57.6 | .800 | 4.75 |
| 85 | 800 | 40.87 | 56.1 | .780 | 7.00 |
| 86 | 900 | 39.38 | 52.0 | .859 | .24 |
| 87 | 900 | 39.98 | 45.0 | .744 | 1.40 |
| 88 | 900 | 40.43 | 40.0 | .662 | 7.00 |
| 89 | 1,000 | 41.81 | 35.0 | .745 | .18 |
| 90 | 1,000 | 39.46 | 30.0 | .638 | .85 |
| 91 | 1,000 | 39.73 | 28.0 | .596 | 1.25 |
| 92 | 1,000 | 39.54 | 25.0 | .532 | 4.90 |
| 93 | 800 | 60.15 | 44.7 | .930 | .65 |
| 94 | 800 | 57.47 | 44.1 | .920 | 3.00 |
| 95 | 800 | 57.26 | 43.2 | .900 | 4.65 |
| 96 | 800 | 57.82 | 40.8 | .850 | 13.00 |
| 97 | 900 | 60.24 | 35.0 | .853 | 1.27 |
| 98 | 900 | 61.22 | 32.0 | .781 | 4.30 |
| 99 | 1,000 | 60.49 | 22.0 | .677 | 1.00 |
| 100 | 1,000 | 63.57 | 20.0 | .615 | 2.10 |
| 101 | 1,000 | 62.77 | 17.0 | .523 | 9.60 |

[a]Test stopped before failure.

TABLE III.- CONSTANTS FOR THE EXPRESSION $\epsilon = \frac{\sigma}{E_s} + A\tau^k \sinh(B\sigma)$

WHICH DESCRIBES THE MATERIAL CREEP BEHAVIOR OF 17-7 PH

STAINLESS STEEL IN COMPRESSION

[$\sigma$ and $E_s$ are in ksi; $\tau$ is in hours]

| T, °F | A | B | k |
|---|---|---|---|
| 700 | $0.86 \times 10^{-5}$ | $3.30 \times 10^{-2}$ | 0.390 |
| 800 | 1.70 | 4.70 | .430 |
| 900 | 9.80 | 4.70 | .400 |
| 1,000 | 22.50 | 6.20 | .475 |

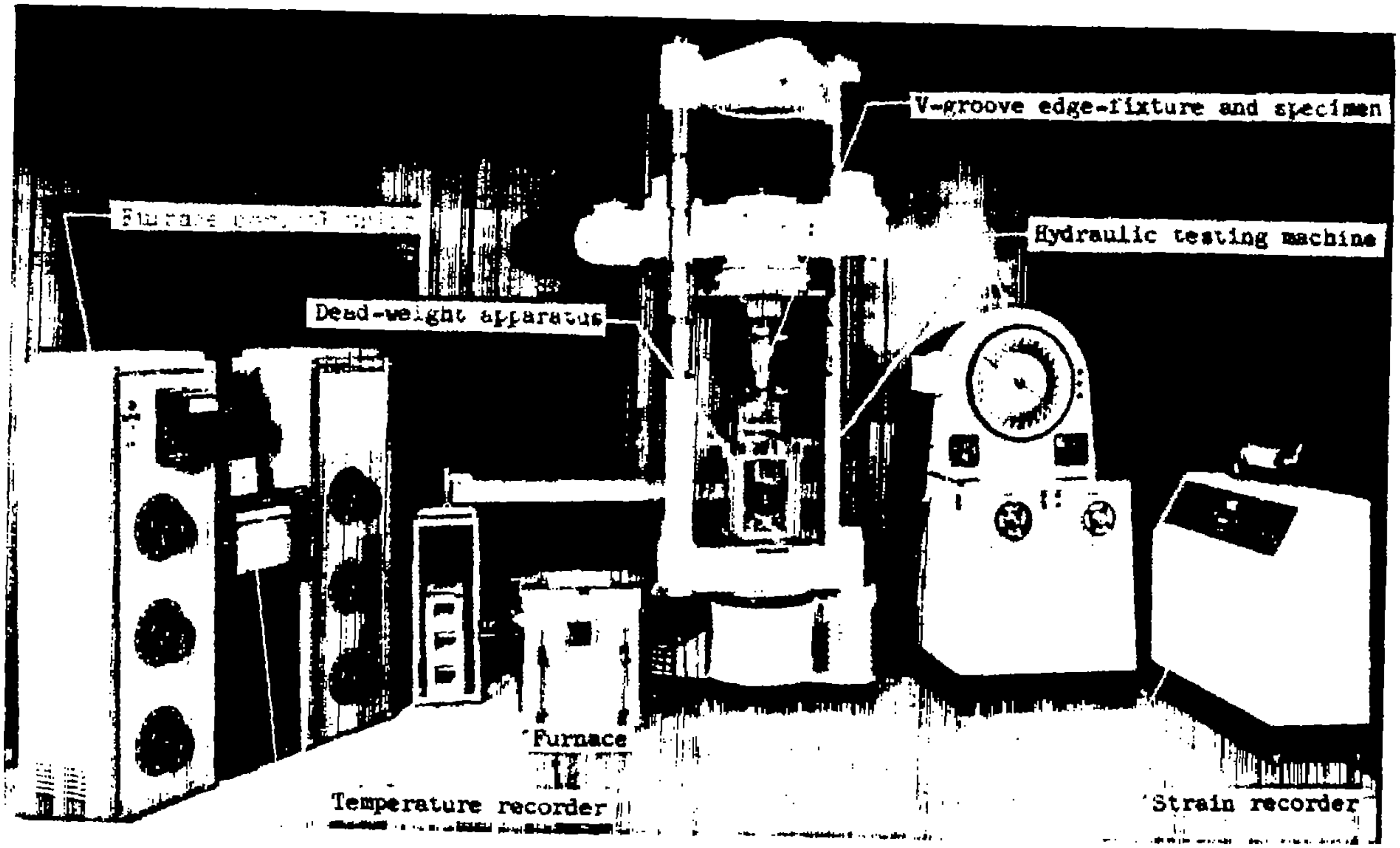



Figure 1.- Testing and recording equipment. L-57-1883.1

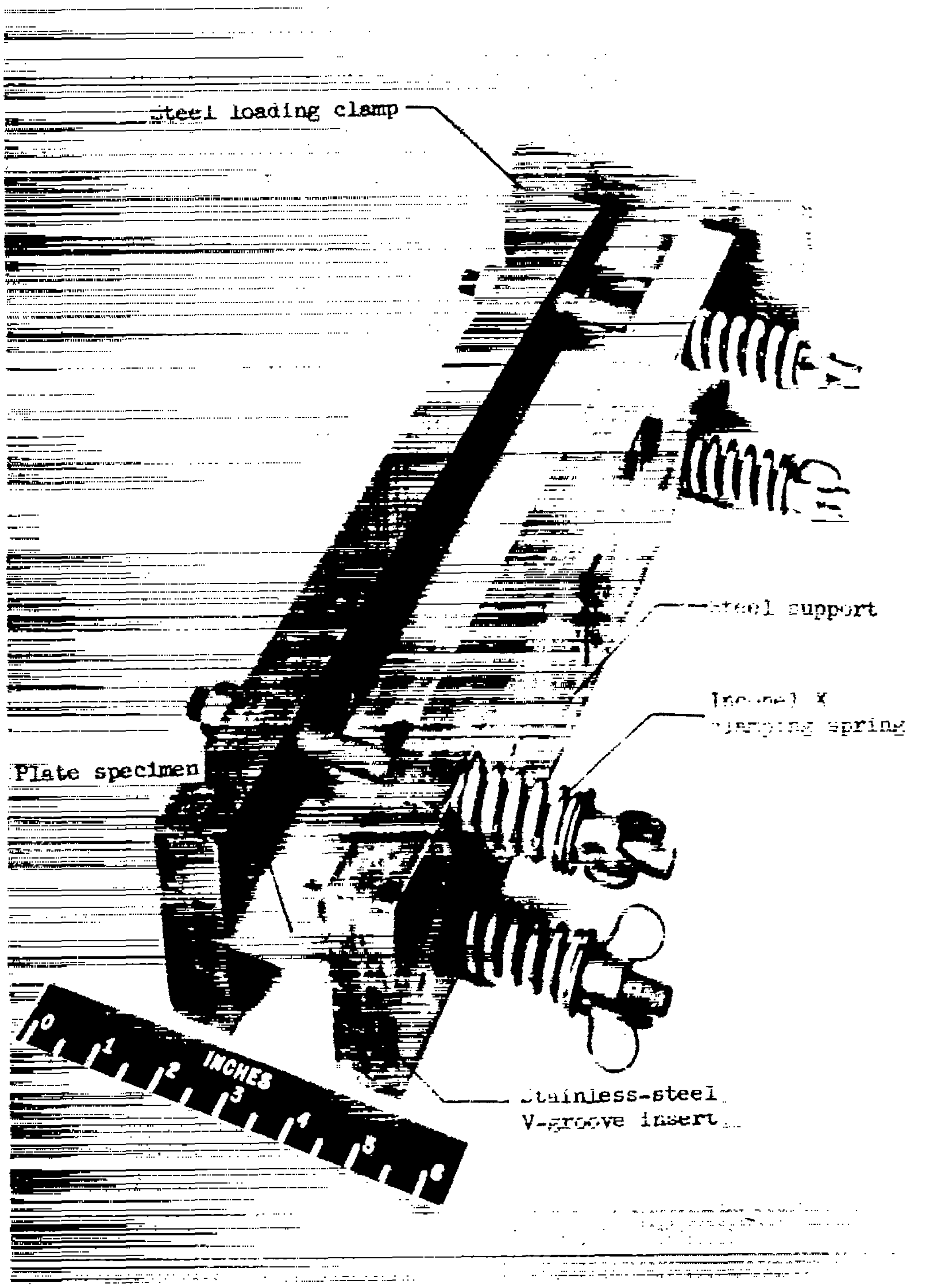



Figure 2.- V-Groove edge support fixture. L-58-858.1

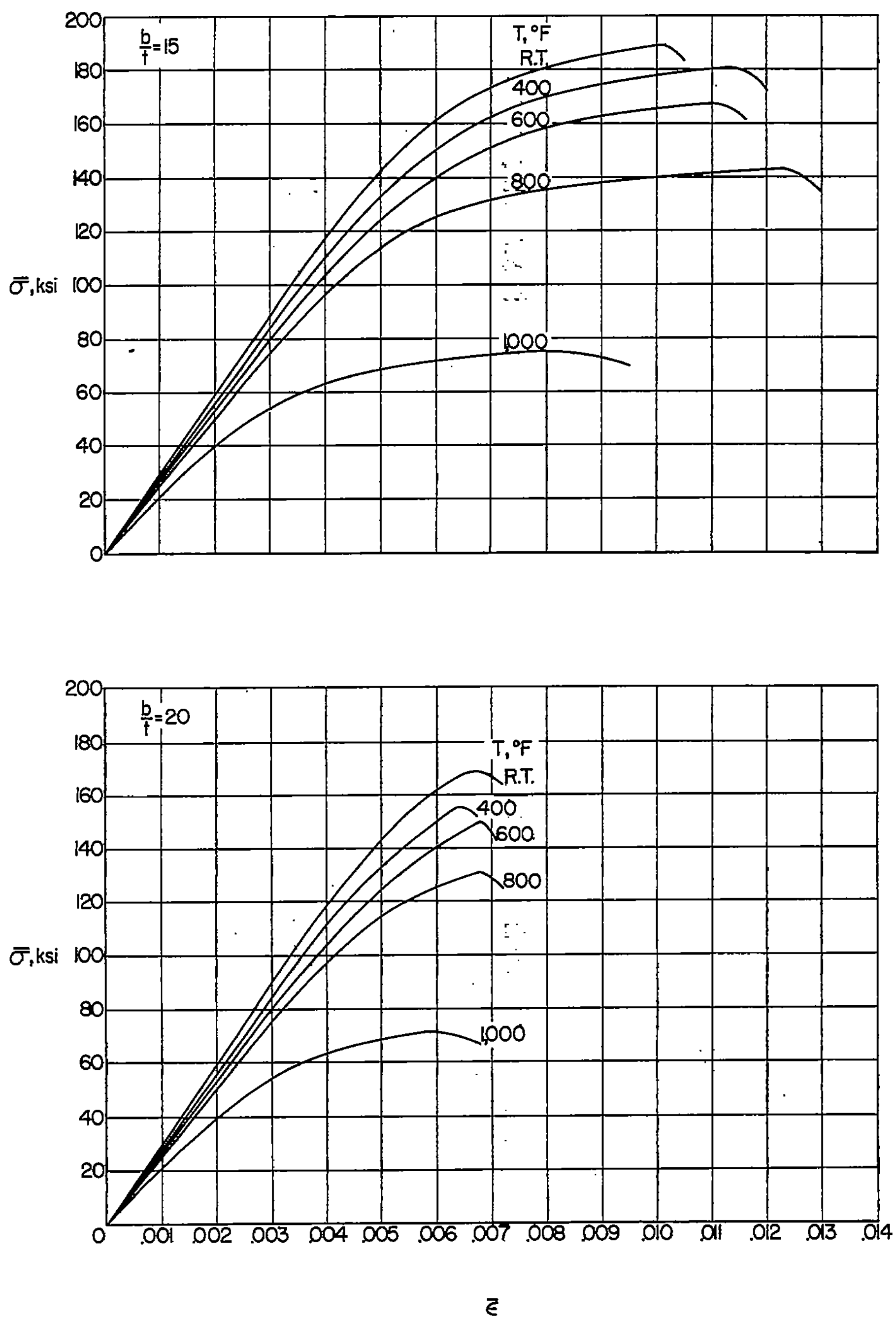



Figure 3.- Average stress against unit shortening for 17-7 PH stainless-steel plates, Condition TH 1,050; $\frac{1}{2}$-hour exposure to temperature.

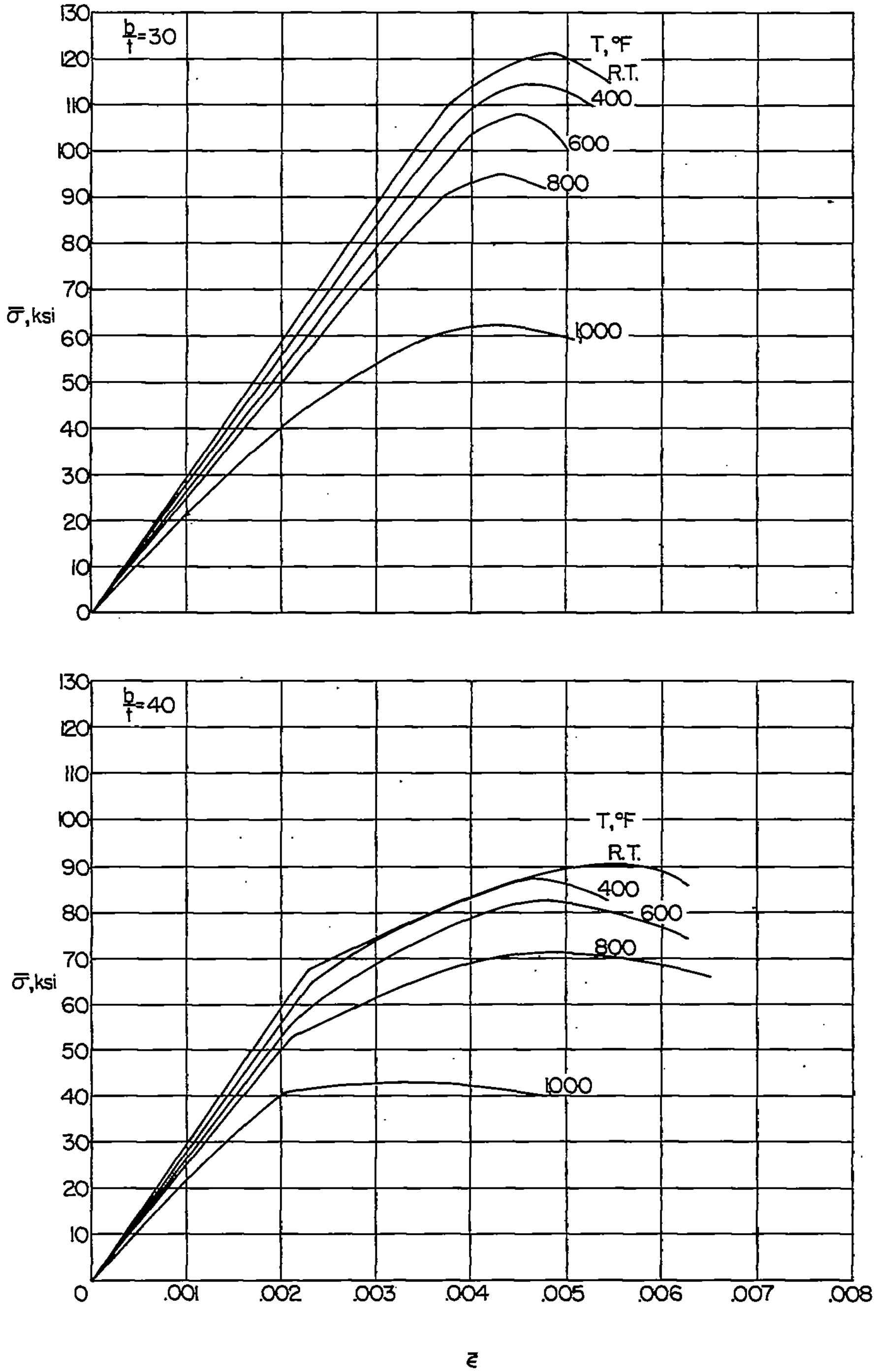



Figure 3.- Continued.

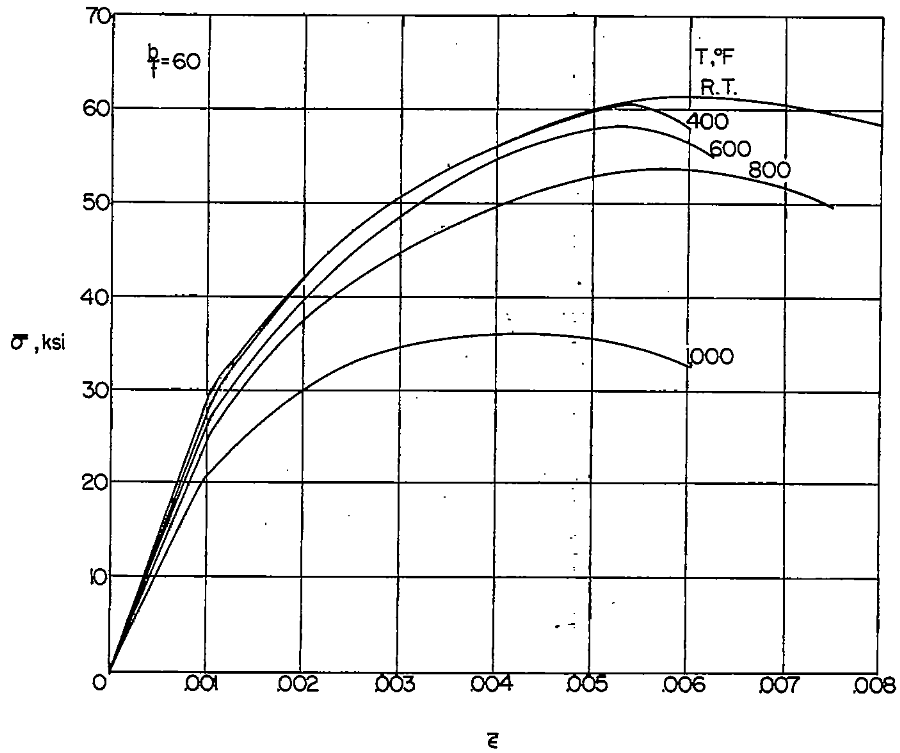



Figure 3.- Concluded.

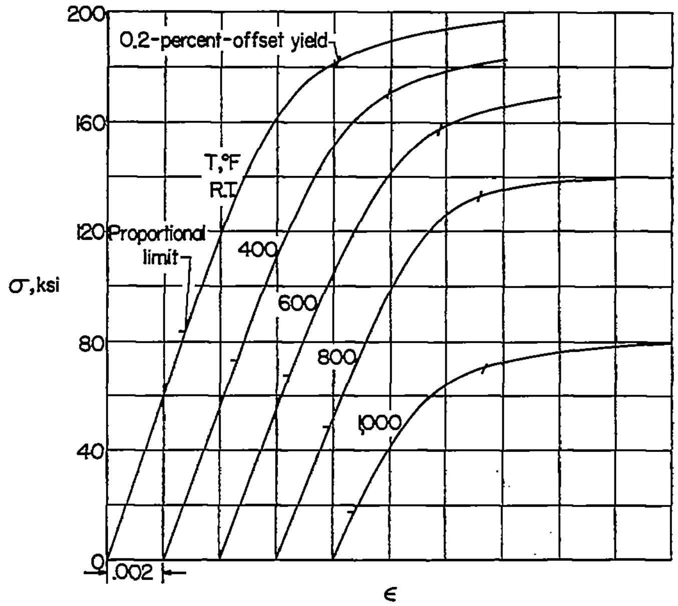



Figure 4.- Compressive stress-strain curves for 17-7 PH stainless-steel sheet, Condition TH 1,050. Strain rate, 0.002 per minute; $\frac{1}{2}$-hour exposure to temperature.

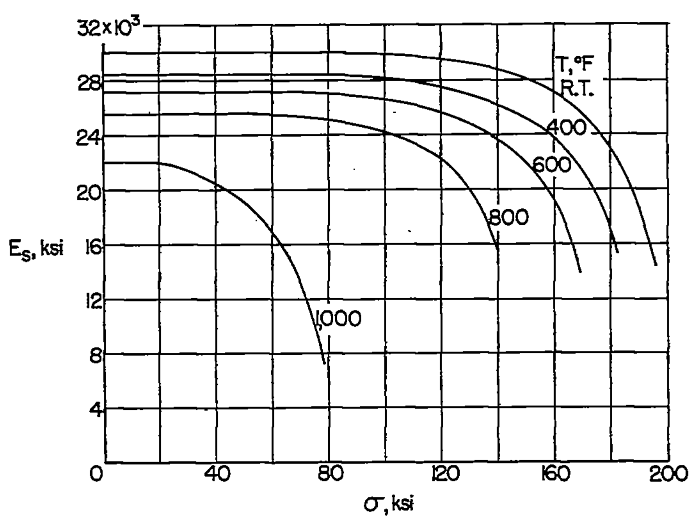



Figure 5.- Variation of secant modulus with stress for 17-7 PH stainless-steel sheet, Condition TH 1,050. Strain rate, 0.002 per minute; $\frac{1}{2}$-hour exposure to temperature.

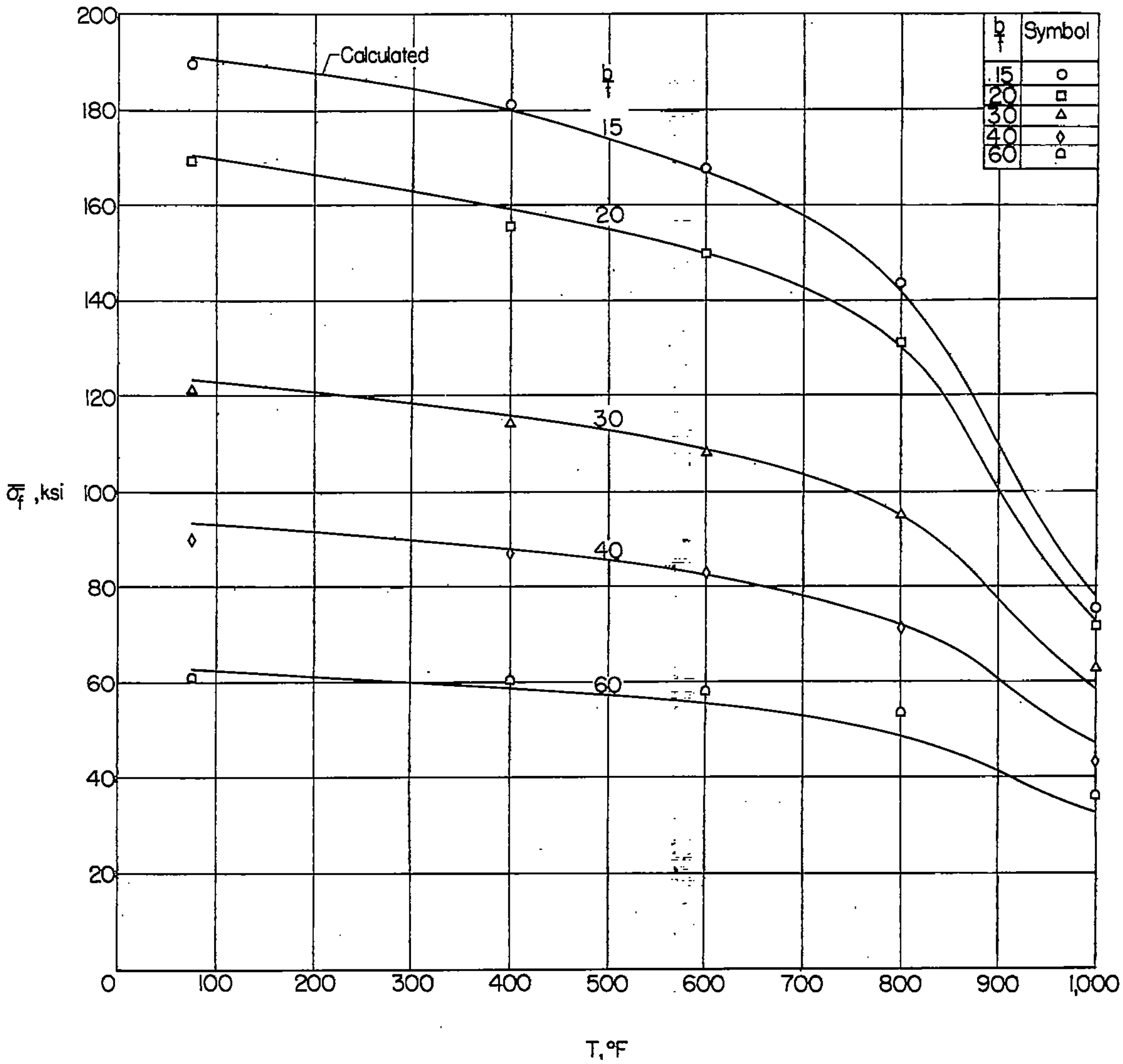
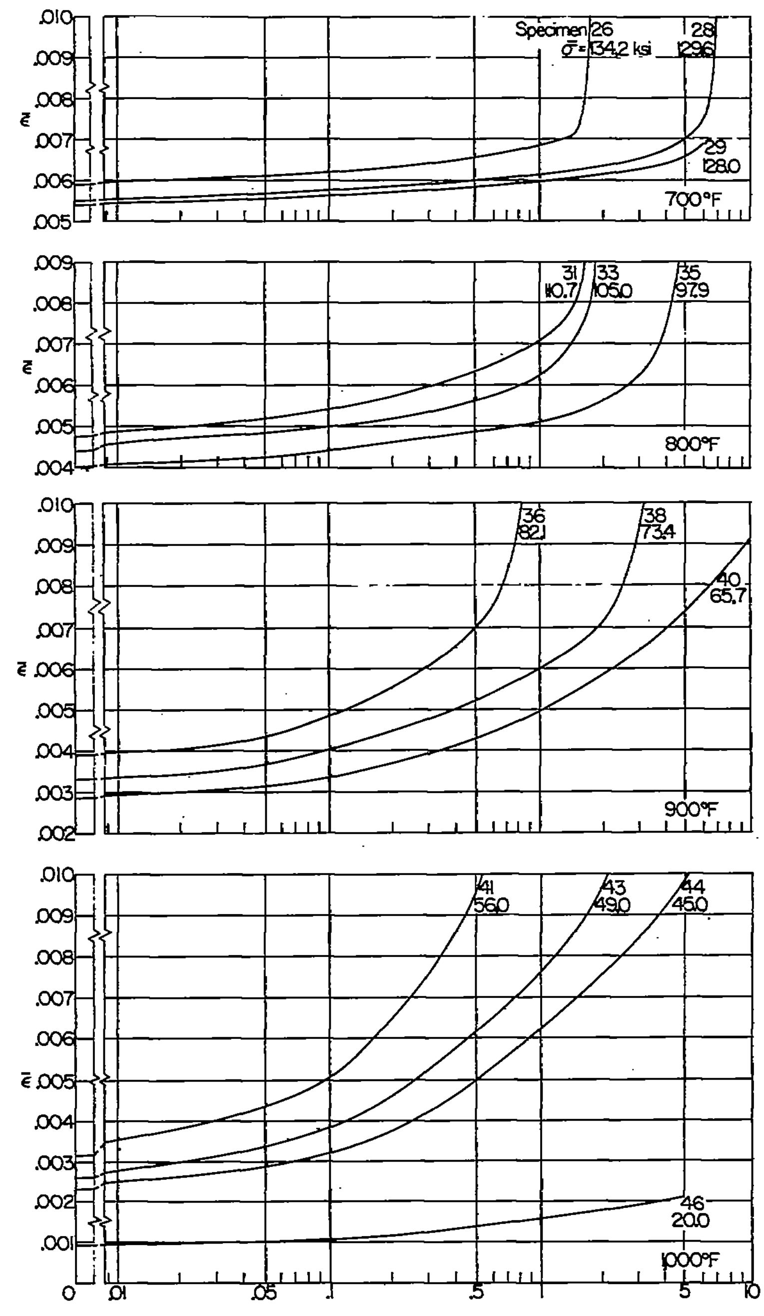
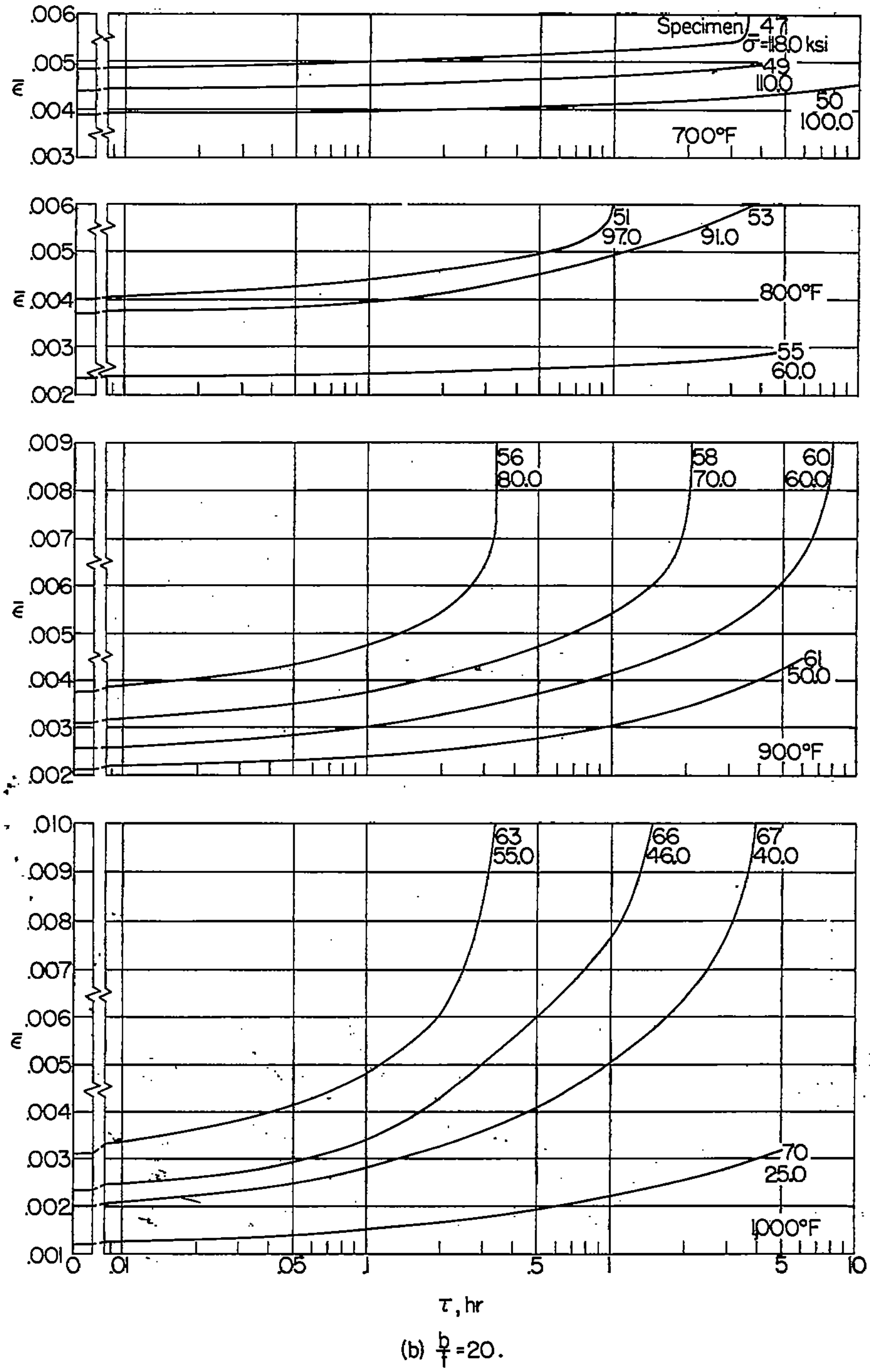



Figure 6.- Comparison of experimental and calculated compressive strength results for 17-7 PH stainless-steel plates, Condition TH 1,050; $\frac{1}{2}$- hour exposure to temperature.



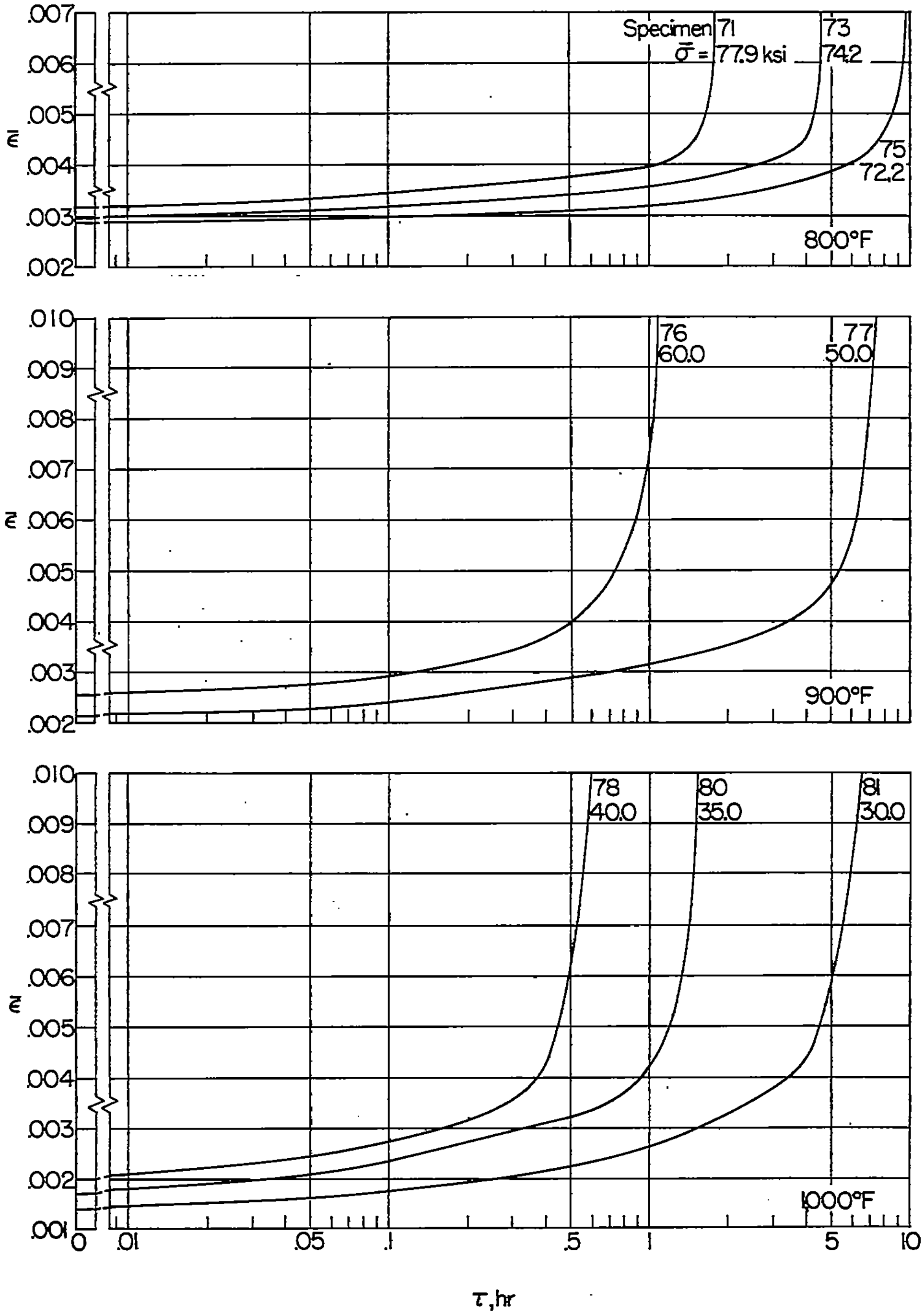

(a) $\frac{b}{t} = 15$.

Figure 7.- Typical creep curves for 17-7 PH stainless-steel plates, Condition TH 1,050.



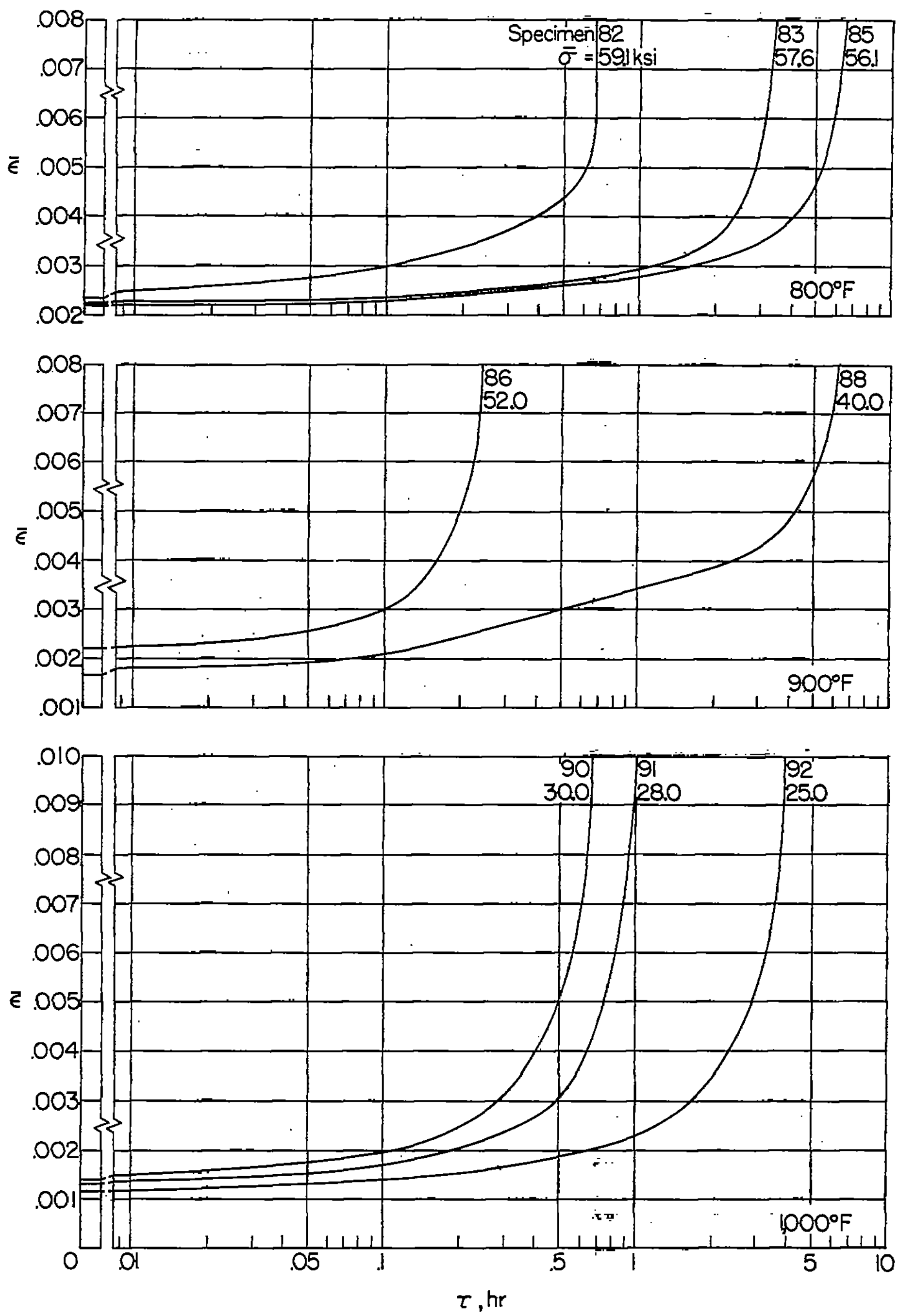

(b) $\frac{b}{t} = 20$.

Figure 7.- Continued.



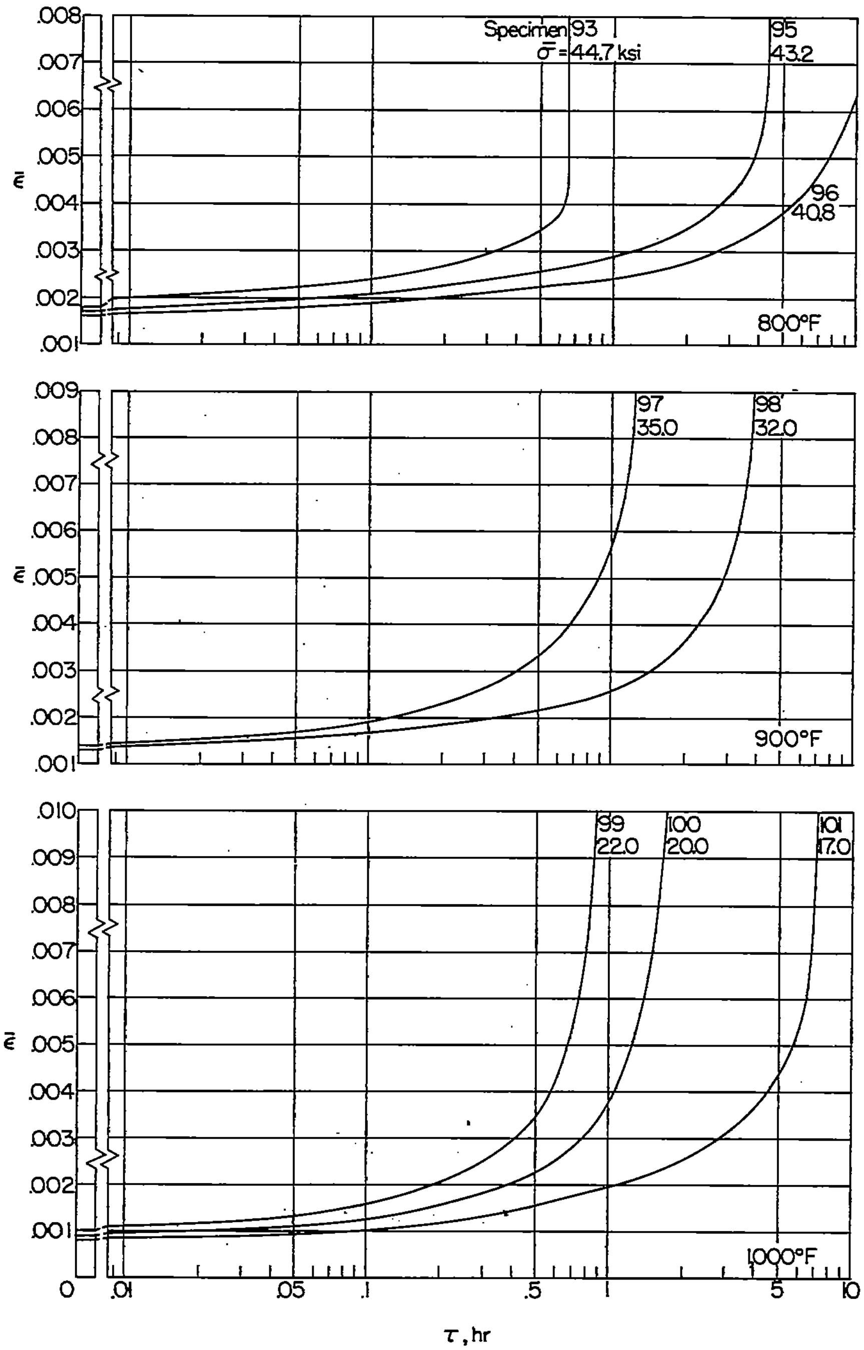

(c) $\frac{b}{t}$ = 30.

Figure 7.- Continued.




(d) $\frac{b}{t}$ = 40.

Figure 7.- Continued.




(e) $\frac{b}{t}$=60.

Figure 7.- Concluded.

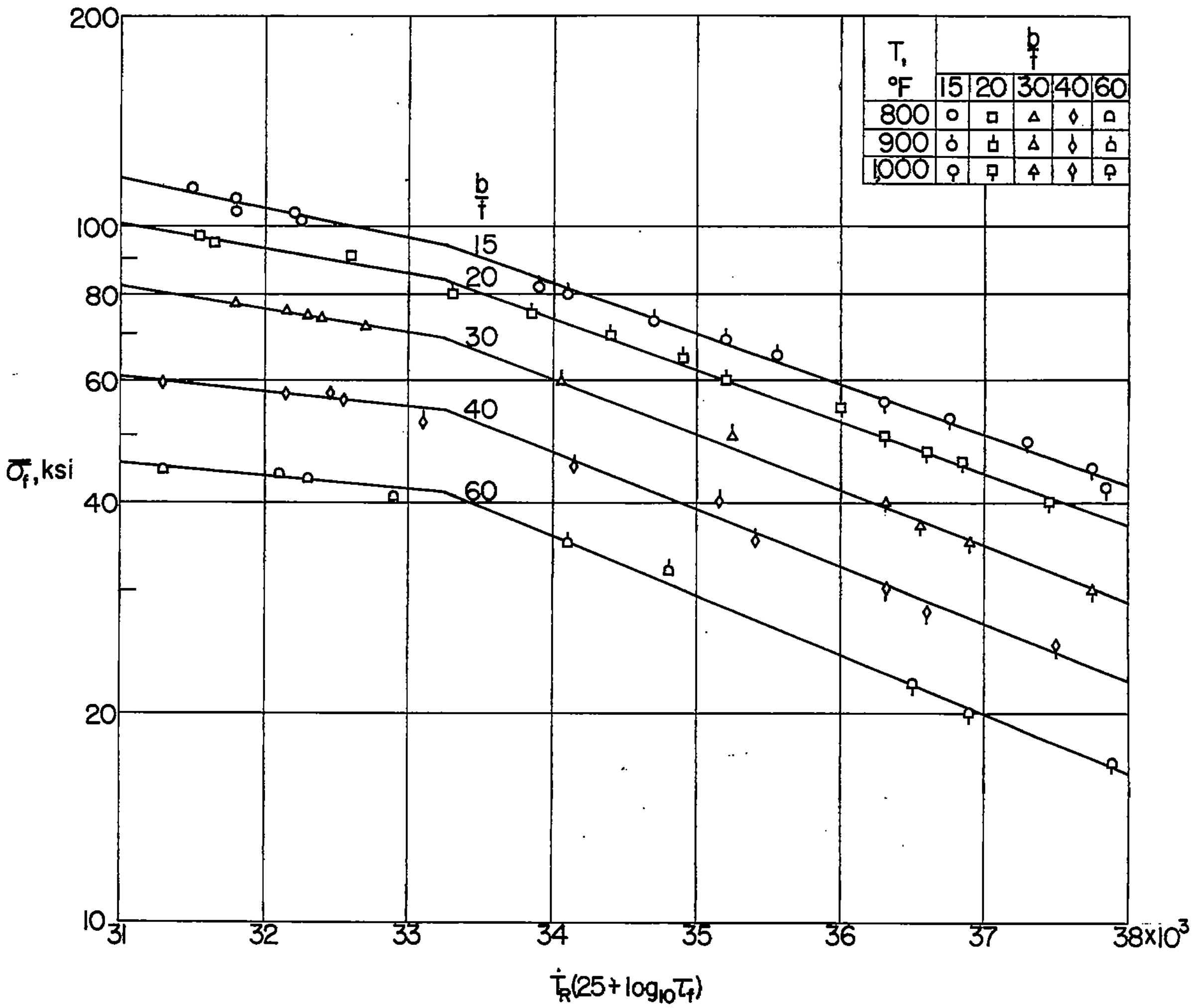



Figure 8.- Master creep lifetime curves for 17-7 PH stainless-steel plates, Condition TH 1,050.

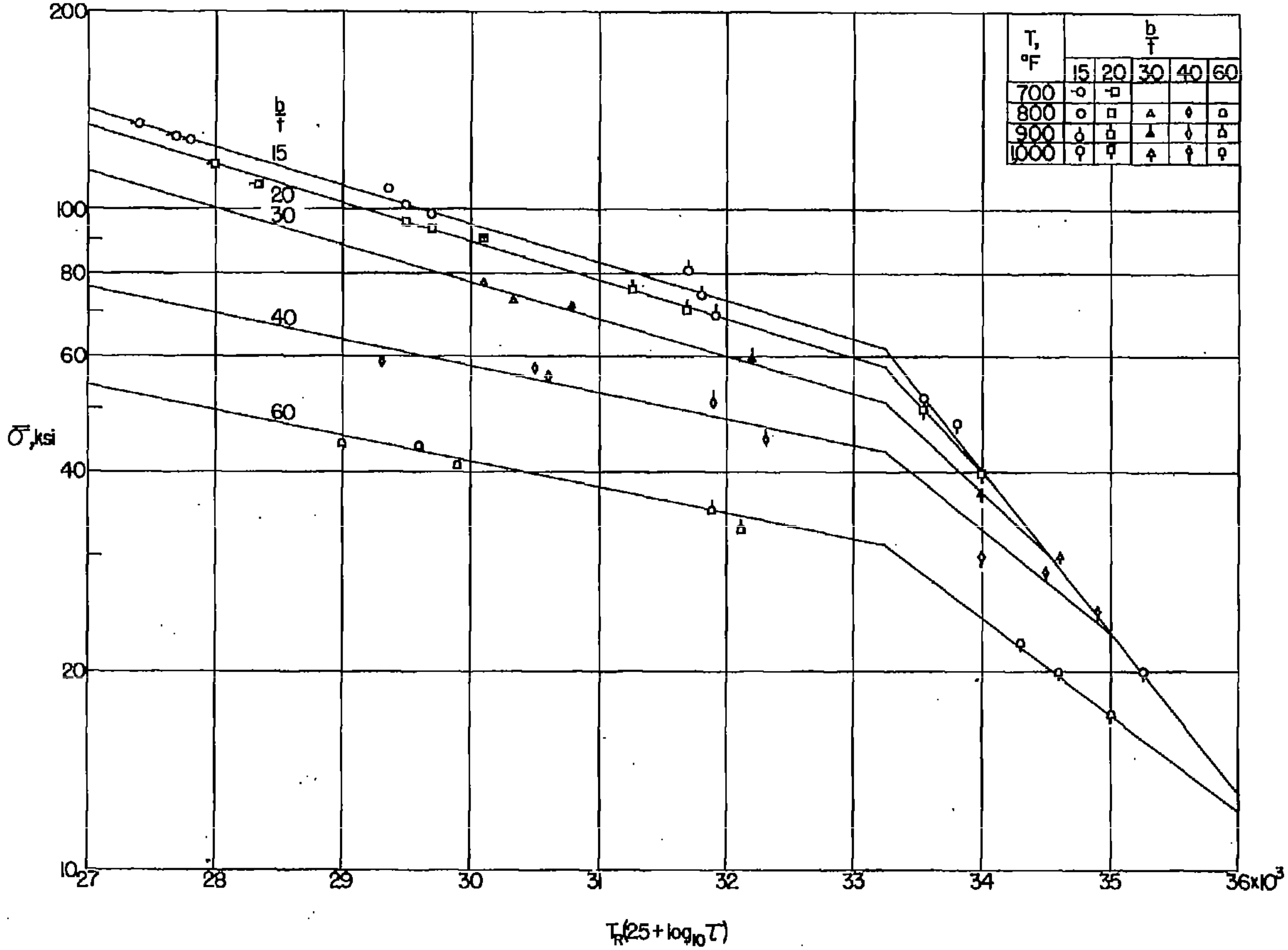



Figure 9.- Stresses at which a creep strain of 0.0002 was attained in 17-7 PH stainless-steel plates, Condition TH 1,050, for various combinations of time and temperature.

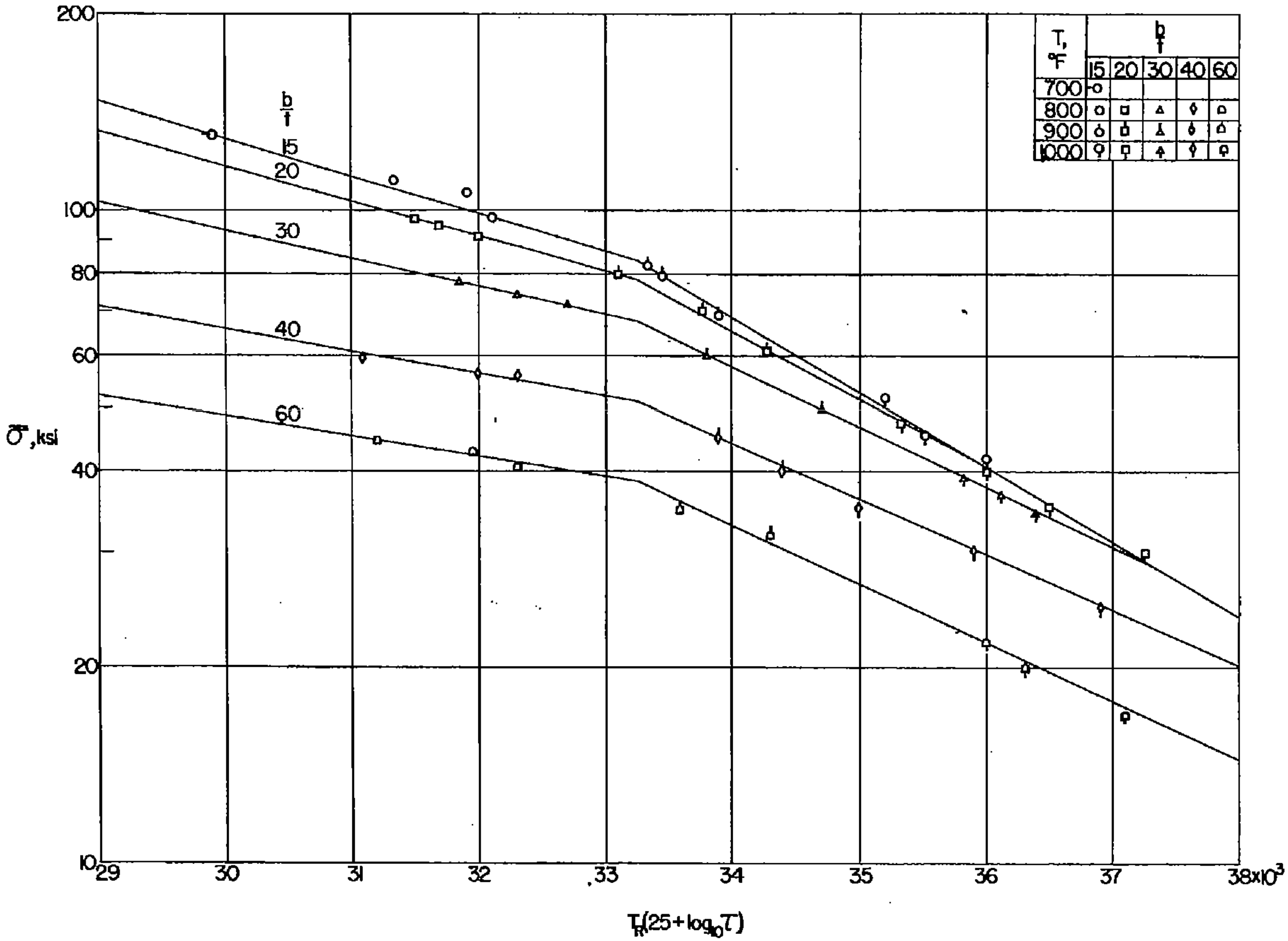



Figure 10.- Stresses at which a creep strain of 0.002 was attained in 17-7 PH stainless-steel plates, Condition TH 1,050, for various combinations of time and temperature.

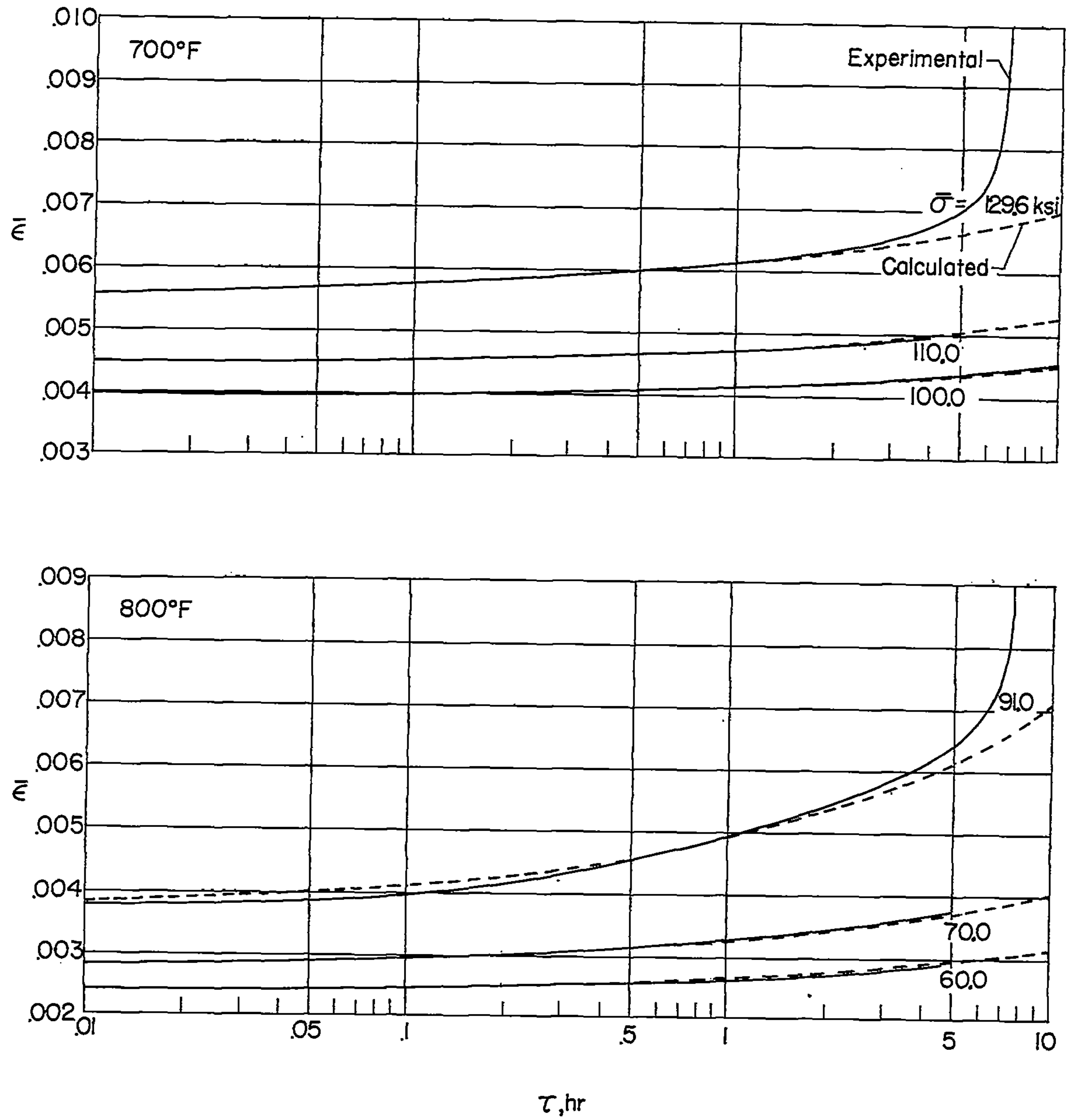



Figure 11.- Experimental material creep curves for 17-7 PH stainless steel, Condition TH 1,050, compared with creep curves calculated from equation (3).

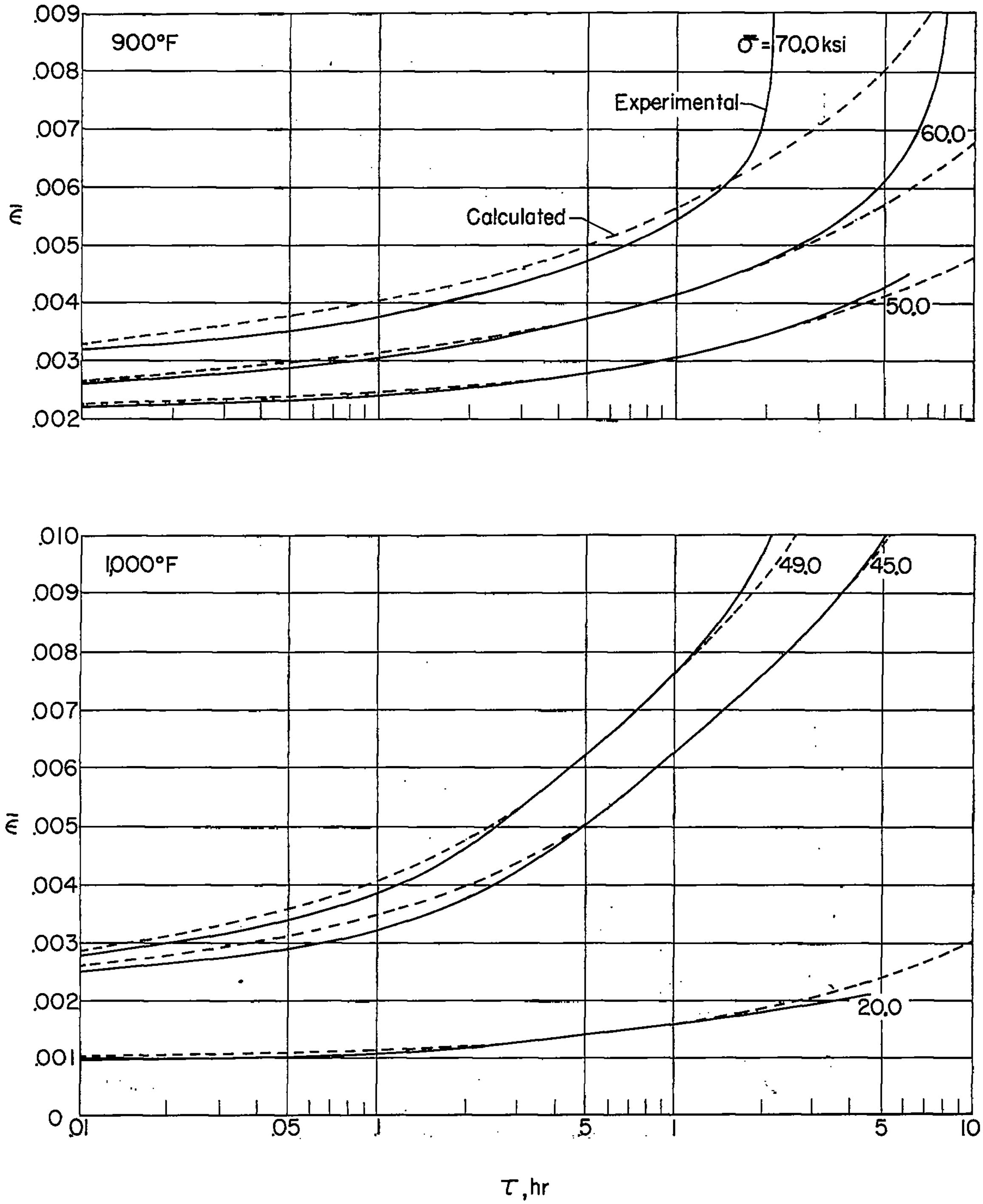



Figure 11.- Concluded.

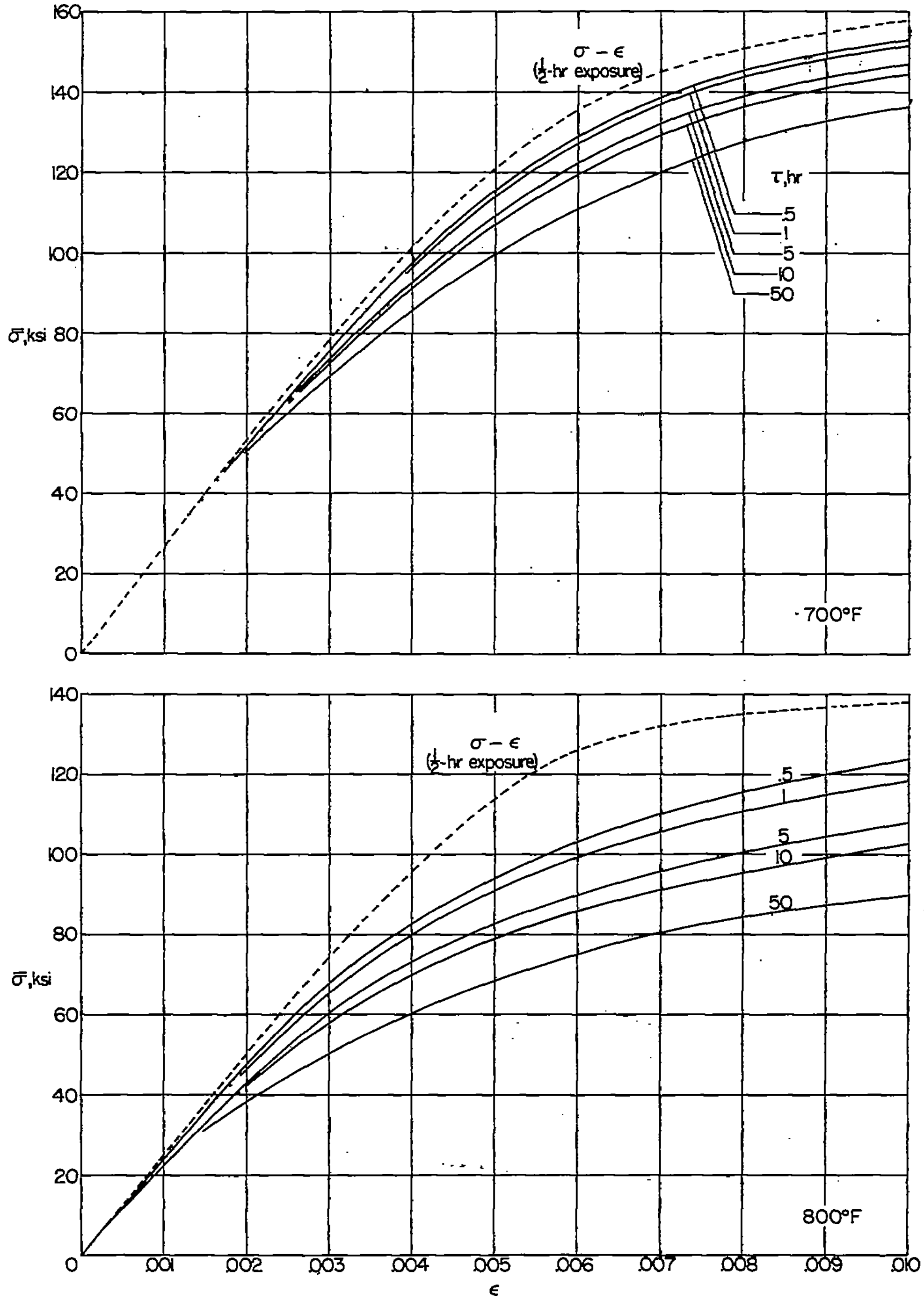



Figure 12.- Isochronous stress-strain curves for 17-7 PH stainless-steel sheet, Condition TH 1,050.

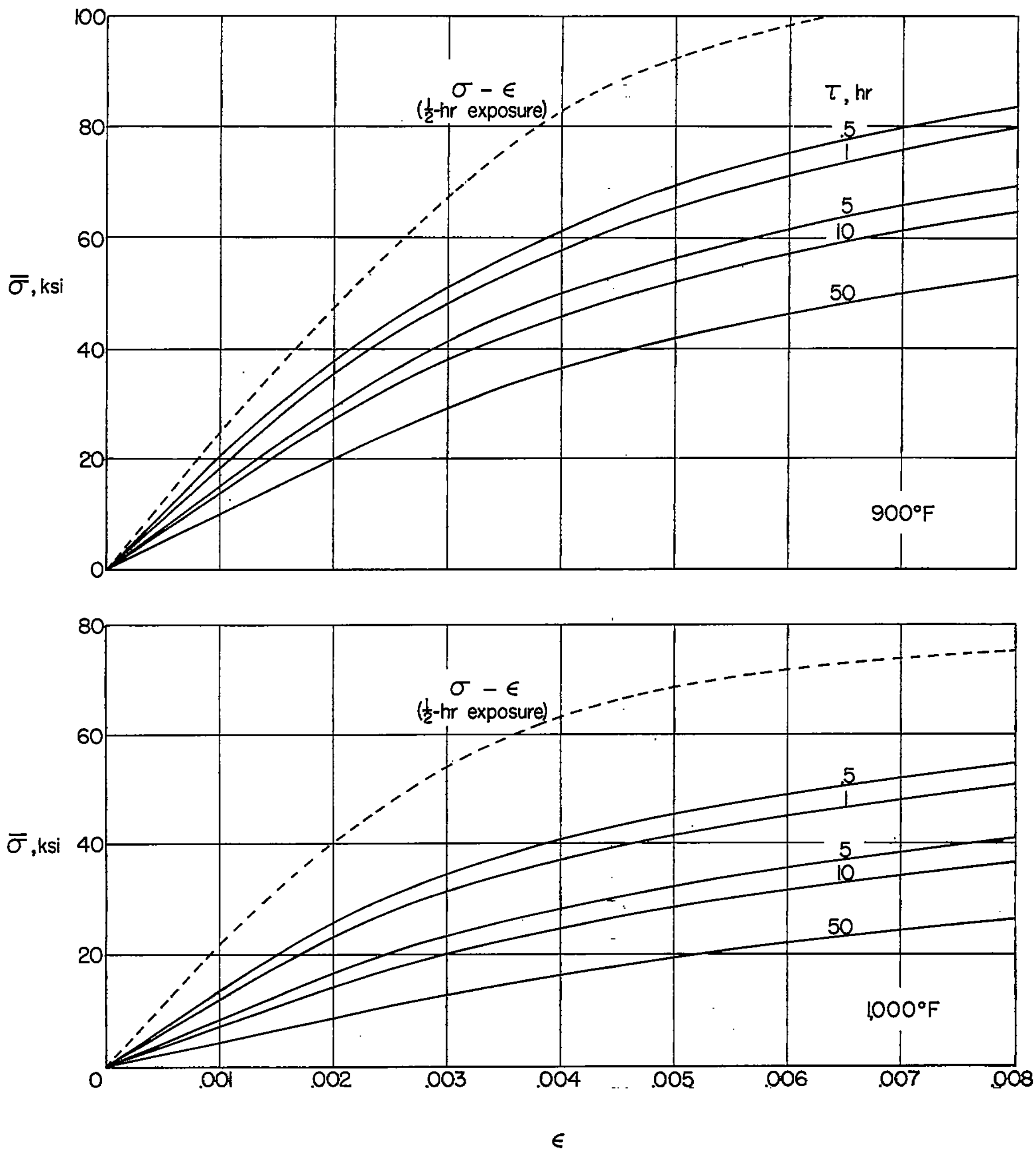



Figure 12.- Concluded.

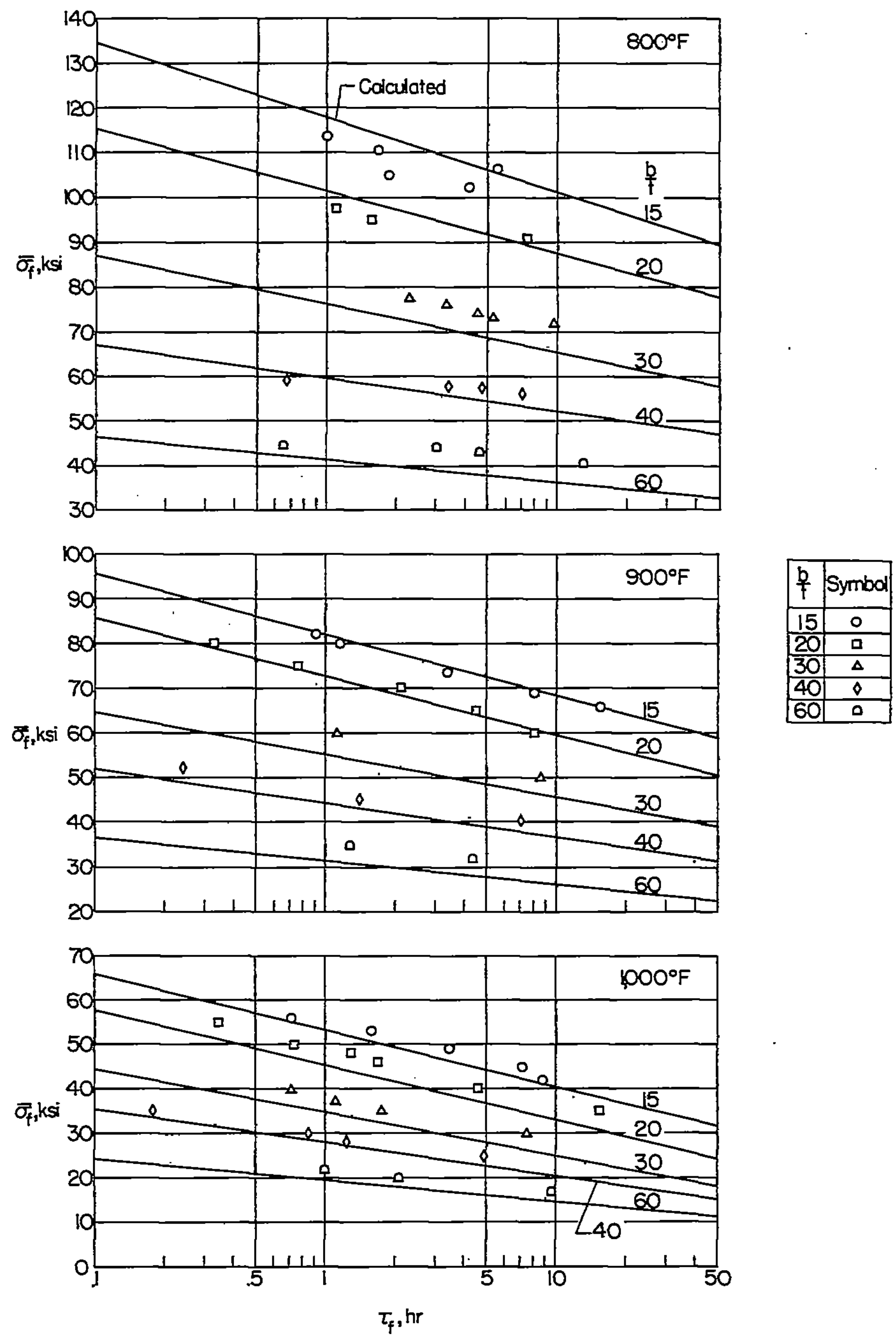



Figure 13.- Comparison of experimental and calculated compressive creep failure stresses for 17-7 PH stainless-steel plates, Condition TH 1,050.